

## A New Species of Leptodactylid Frog, Genus *Eleutherodactylus*, from the Cordillera de Talamanca, Costa Rica

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*Abstract.*—*Eleutherodactylus rayo* a distinctive new species sharing features of the *fitzingeri* and *rugulosus* groups occurs along the Pacific slopes of the Cordillera de Talamanca of Costa Rica. Karyologically the new form most closely resembles *El. vocalis* of northwestern Mexico and certain populations of frogs from eastern Mexico, formerly referred to *El. rugulosus* but for which the name *El. berkenbuschii* W. Peters, 1870, is revived. Unlike other members of the *rugulosus* group which have  $2N = 20$ , *berkenbuschii*, *rayo* and *vocalis* have  $2N = 22$  and approach *El. talamancae* of Coast Rica and Panama, a member of the *fitzingeri* group, in karyotypes.

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During the past 20 yr of work in Costa Rica, the University of Southern California field teams have accumulated a number of distinctive or unique frogs that appeared to be representative of species not previously known to science. In most cases formal description has been delayed pending collection of additional material. A single example of the genus *Eleutherodactylus* falling into this category was originally collected by Roy W. McDiarmid in 1964 from a remote area on the Pacific slope of the Cordillera de Talamanca. Subsequently other specimens of this form were taken from 1972-1976 in the same mountain range along the Carreterra Interamericana.

The new species belongs to the *fitzingeri* group (*sensu* Lynch, 1976) and is somewhat intermediate in characteristics between the *fitzingeri* and *rugulosus* groups as used by Savage (1975, 1976). It is called:

*Eleutherodactylus rayo*, new species

Fig. 1

*Holotype.*—LA 127669, an adult male from the second sabana on the trail from Finca El Helechales to Sabanas Esperanza, 5 km, airline, east of Finca El Helechales, Canton de Buenos Aires, Provincia Puntarenas, Costa Rica, 1640 m; collected by Roy W. McDiarmid, October 6, 1964.

*Diagnosis.*—The new form superficially resembles several lower Central American species of the *fitzingeri* and *rugulosus* groups. It differs from members (*andi*, *fitzingeri* and *talamancae*) of the former group, that share with it the feature of having the webs between toes III-IV extending at most only slightly distal to the proximal subarticular tubercle in having a well-developed calcar. All other members of the group have substantially more toe webbing, which extends nearly to distal subarticular tubercle (III) between toes III-IV and to halfway between proximal and penultimate subarticular tubercles (IV).



Fig. 1. *Eleutherodactylus rayo*, male paratype (CRE 3980) from Quebrada Fortuna at Carreterra Interamericana, Provincia de San Jose, Costa Rica, 1750 m. DeWeese photograph.

Within this cluster of slightly webbed forms it may be distinguished further by differences in posterior thigh coloration which is uniform reddish brown (*talamancae*), brown with discrete small light spots (*fitzingeri*) or dark chocolate with very large light spots (*andi*). The posterior thigh surfaces of *rayo* are essentially a uniform dark purple in life and preservative.

*El. rayo* is distinguished from members of the *rugulosus* group in having a well-developed calcar and in having greatly enlarged emarginate disks on fingers III–IV, while the disks are rounded, not greatly enlarged and never emarginate in the latter group. The dark purplish coloration of the hindlimb surfaces uniquely distinguishes *El. rayo* from all other known members of the *fitzingeri* and *rugulosus* groups in Central America.

*Summary of characteristics.*—General: Head about as wide as long. Nostril closer to tip of snout than to eye. Loreal outline slightly sloping. Snout profile, and canthus rostralis round. Dorsal outline of snout subelliptical. Choanae ovoid; vomerine teeth located between but behind level of choanae in two transverse series separated at the midline. Vocal slits and internal vocal sacs in males. Tympanum approximately  $\frac{1}{2}$  height of orbit; internal, indistinct; round in males oval in females. Skin of head and dorsum smooth; upper eyelid with a single tubercle. Finger II longer than I. Finger disks on I–II rounded and expanded, on III–IV emarginate; about 2 times as wide as finger on III–IV. All fingers have well developed lateral fringes. Whitish nuptial pads on thumbs of male. Subarticular tubercles flattened, round to ovoid in outline, globular; no supernumerary tubercles; thenar tubercle large, elongate; palmar tubercle large ovate; no acces-

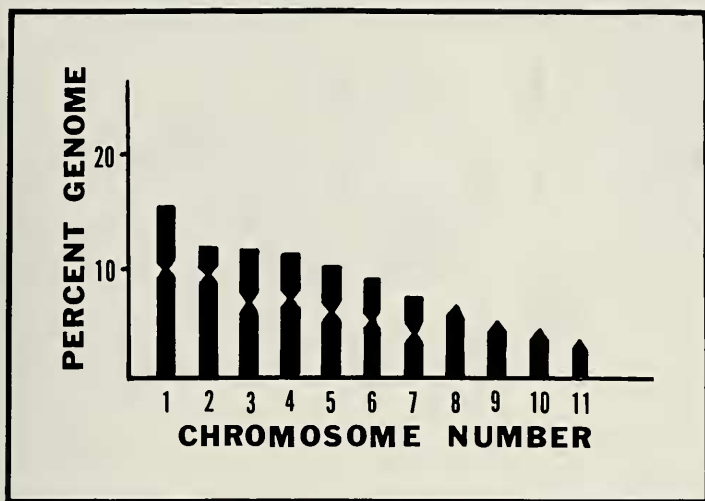


Fig. 2. An idiogram of the karyotype of *Eleutherodactylus rayo*.

sory palmar tubercles. Calcar present. Toe disks palmate on I, emarginate on II–IV and rounded and expanded on V; about 1.5 times as wide as toe on IV. Toe fringes well developed. Toes webbed only basally. Modal toe webbing formula: I 2<sup>-</sup>–2<sup>+</sup> II 2–3 III 3–4<sup>+</sup> IV 4<sup>+</sup>–3<sup>-</sup> V. Subarticular tubercles projecting, ovoid in outline, obtuse to conical in profile; supernumerary tubercles lacking; outer plantar tubercle round, ¼ size of oval inner tubercle. Inner tarsal fold well developed. Venter smooth.

*Coloration.*—Base color of top of head, body and limbs a deep dark brown with a definite bluish purple cast; in preservative; in life deep bluish purple, adult females slightly lighter and tending toward tan as compared to the deep purple males; upper surface of snout light gray in some examples; often an interocular dark bar bordered anteriorly by a light area; upper lips with three dark bars in males; bars suggested by dark areas along mouth margin in females; a definite narrow supratympanic dark mark runs from middle of eye backward above tympanum and curves downward to shoulder. Dorsum uniform or with dark suprascapular spots or blotches in some examples; sometimes with a narrow white light line along median raphe; one adult female with a broad mid-dorsal light stripe bordered on either side by a broad dark area. Males often with some blotches of olive green in life. Dorsal and anterior surfaces of limbs uniform or with broad crossbars of dark pigment. Posterior surface of thigh dark purplish with obscure small light punctations. Throat heavily marked with dark pigment; with a narrow median light line. Venter light with a heavy mottling of dark pigment. Ventral surface of hind limbs marked like posterior thigh surface; plantar surface uniform purple. Groin and flanks similar in color to dorsum.

*Measurements.*—In this section the notation gives the mean followed by the range in parentheses. Standard lengths (distance from snout to vent) are given in millimeters; other measurements as percentages of standard length.

Standard length, adult males (N = 10) 40.0 (37.4–45), adult females (N = 10) 53.6 (38.2–70.9); head length, males 38.0 (34.9–41.0), females 37.3 (35.1–38.6);

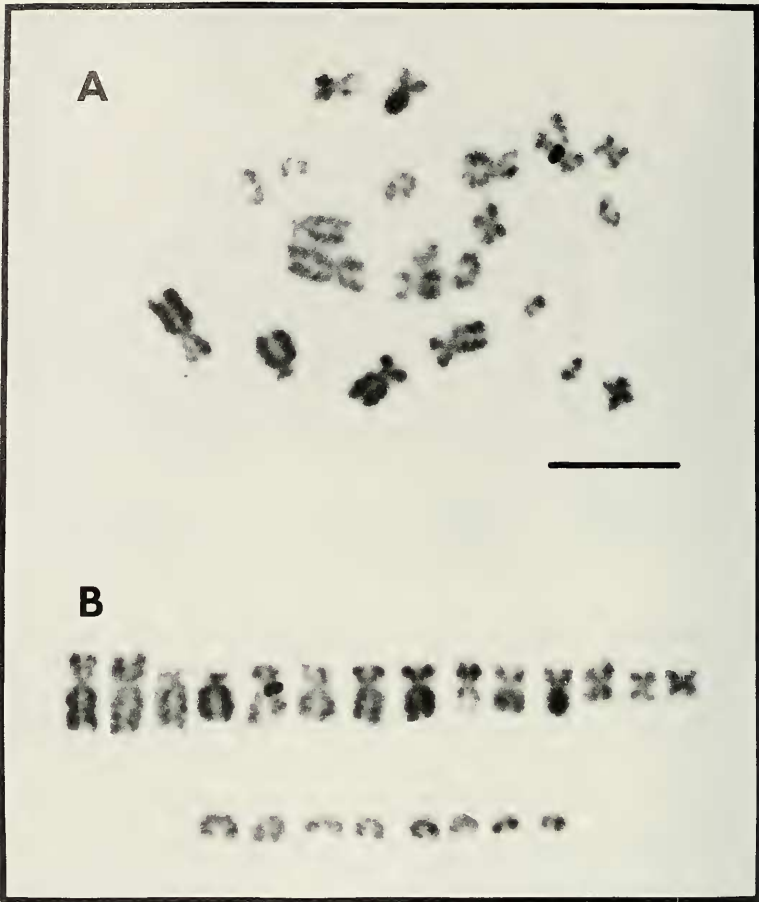


Fig. 3. A representative metaphase spread (A) and karyotype (B) for *Eleutherodactylus rayo*.

head width, males 38.2 (35.8–40.5), females 41.0 (39.0–42.7); snout length, males 18.4 (17.6–19.3), females 18.6 (17.5–19.1); loreal length, males 10.6 (9.1–11.9) females 8.1 (7.4–8.9); length of orbit, males 14.7 (13.3–16.4), females 12.9 (11.7–15.2); height of tympanum, males 8.6 (7.3–9.8), females 5.9 (5.1–6.5); hindlimb length, males 210.7 (203.1–217.5), females 212.5 (209.6–215.6); tibia length, males 65.3 (62.7–66.4), females 57.4 (55.8–58.9). Note non-overlapping in tympanum height and tibia length to produce strong sexual dimorphism.

*Karyotype*.—Seven paratypes (CRE 3184[2], 3236–39, 9770) were examined karyologically using the technique of Patton (1967) as modified by Lowe et al. (1966). 122 spreads were counted, three were photographed and the individual chromosomes measured (Table 1), and an idiogram constructed (Fig. 2).

The diploid number (2N) is 22 and the *nombre fundamental* (N.F.) is 36. The chromosomes form a gradually descending series with no obvious size groupings. Chromosome pairs (centromere placement according to the system of Levan et al. 1964), 1, 3, 5, 6 and 7 are metacentric; 4 is submetacentric; 2 is subacrocentric and 8–11 are acrocentric (Fig. 3).

Table 1. The centromeric indices (C.I.) and percent genome values (G) for the 11 pairs of chromosomes in the karyotype of *Eleutherodactylus rayo*.

Chromosome Number	C.I.	G.
1	1.64	16.2
2	3.92	12.2
3	1.44	12.0
4	1.72	11.8
5	1.27	10.5
6	1.34	9.3
7	1.12	7.6
8	7.00	6.8
9	7.00	5.2
10	7.00	4.5
11	7.00	3.7

*Habitat*.—The male holotype was captured during the day while calling from a bromeliad during a heavy rain. Most of the paratypes were collected along the margins of a small stream during the daytime. They were found under debris or were apparently frightened out of their hiding places by the collector's activity and were hopping along the stream banks or across the shallows.

*Distribution*.—Rainforests of the upper portion of the premontane and lower portion of the lower montane slope of the Pacific face of the Cordillera de Talamanca of southwestern Costa Rica, between 1600–1850 m (Fig. 4).

*Localities*.—COSTA RICA: PUNTARENAS: 5 km E Finca El Helechales, 1640 m (LA 127669); SAN JOSE: Quebrada Fortuna at Carreterra Interamericana, 1750 m–1840 m (CRE 3184, 3232–33 3236–39, 3979–80, 6599, 8710–12, 9769; KU 65986); Rio Payner at Carreterra Interamericana, 1480 m (CRE 9770). All examples from San Jose Province are paratypes.

The name *rayo* is an arbitrary combination of letters that happens to mean lightning in Spanish. The name is an allusion to Roy W. McDiarmid, who first collected the species, as recognition for his work on the Costa Rican herpetofauna. Those who know Roy well will discern other reasons why this name is appropriate.

#### Relationships

The speciose genus *Eleutherodactylus* has always presented a serious problem to the systematic herpetologist interested in establishing relationships among morphologically similar forms. Currently about 350–400 species are recognized in the genus which ranges throughout the Neotropical region. The morphology of the group ranges from huge, stream-adapted toad-like species through moderate-sized frog-like terrestrial forms, arboreal treefrog-like species with huge finger and toe disks to large toad-like forest floor burrowers. While distantly related forms seem very distinct, the features of external morphology within the genus are recombined over and over again in a mosaic pattern that tends to make recognition of natural subdivisions difficult, while closely related forms often differ only slightly in these same features. One recourse in this situation has been to establish a series of species groups within the genus by clustering species that

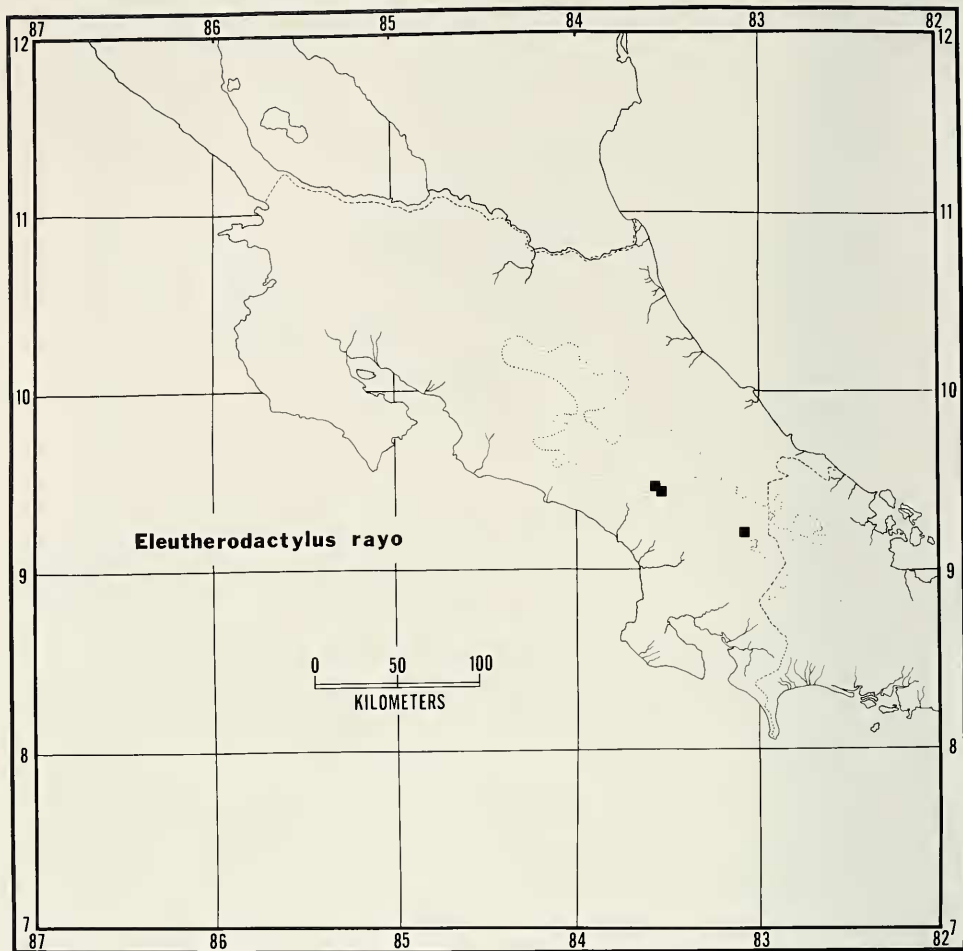


Fig. 4. Distribution of *Eleutherodactylus rayo*. The dotted line indicates the 1500 m contour.

are extremely similar morphologically and are probably phylogenetically from the same evolutionary lineage (e.g., Savage, 1976). Another alternative (Lynch, 1976) has been to group the species at a higher level (subgeneric) without giving the groups formal taxonomic status. Unfortunately the first method does not provide a sound framework for establishing the evolutionary history of the genus, while the second creates infrageneric divisions based on "key" characteristics of external and skeletal morphology that are of dubious evolutionary cogency.

It is clear from the study of jaw musculature (Starrett, 1968), serum proteins (Harris, 1973) and karyology (DeWeese, 1976) that a series of at least six major evolutionary lineages are subsumed under the genus *Eleutherodactylus*. In most cases these lineages do not correspond to the groupings established on external and skeletal morphologic grounds (Lynch, 1976) and suggest that the time is premature for an attempt to establish higher-level divisions based solely on traditional taxonomic (key) characters.

*El. rayo* morphologically is allied to the *fitzingeri* and *rugulosus* groups (Sav-

age, 1975, 1976). Lynch (1976) proposed to place these groups together as the *fitzingeri* group. While this is not the place to consider fully the weaknesses of Lynch's (1976) system, it must be noted that both *El. andi* of Costa Rica and *El. rayo* within this group have emarginate finger disks to negate one feature (ungual flap not indented) used to characterize this division. In addition one population referred to *El. rugulosus* (Savage, 1975) has the first finger shorter than the second, while Lynch (1976) characterizes the *fitzingeri* as having the converse situation.

Nevertheless there can be little doubt that the two groups recognized by Savage (1976) are closely allied. This relationship is further supported by the condition of the jaw muscles: depressor mandibulae with a single slip originating on the dorsal fascia but a few fibers coming from the squamosal (dfsq) or with a single slip originating on the dorsal fascia but a few fibers coming from the squamosal and annulus tympanicus (dgsqat) and adductor mandibulae externus superficialis present (e). Formulae for jaw muscles after Starrett (1968), are inadvertently misstated for the *rugulosus* group in Savage (1975). Karyologically the two groups are also similar with the *fitzingeri* group having  $2N = 22$  and  $N.F. = 36-40$  and the *rugulosus* group with  $2N = 20-22$ , and a  $N.F. = 36$ .

In terms of morphology *El. rayo* is distinct from all other members of the *fitzingeri* and *rugulosus* groups in having large emarginate finger and toe disks and a well-developed calcar. The only other species in these groups with similar disks, *El. andi* of Costa Rica, lacks the calcar and has a bold contrasting thigh pattern of large light spots on a dark brown background.

The jaw muscle formula for the new form is  $dfsqat + e$ . It seems likely that the differences between  $dfsq$  and  $dfsqat$  are trivial, since only a few muscle fibers are involved. The latter condition is not currently known to occur in the *fitzingeri* group while it does appear in some *rugulosus* group members (e.g., *El. brocchi* of Guatemala).

Karyologically *El. rayo* agrees in diploid number ( $2N = 22$ ) and *nombre fundamental* (36) with *El. talamancae* of Costa Rica and Panama (in the *fitzingeri* group) and within the *rugulosus* group with *El. vocalis* of northwestern Mexico and the *rugulosus*-like populations of eastern Mexico (populations 1-2 of Savage, 1975). Other leptodactylids with the same numbers are: *El. decoratus* of Mexico (*alfredi* group, Lynch, 1976); and *Hylactophryne augusti*, a close *Eleutherodactylus* relative; *Leptodactylus podicipinus* and *L. wagneri* of South America. Of these forms the karyotype of *El. rayo* most closely resembles that of the *rugulosus*-like populations of eastern Mexico.

These data confirm the uniqueness of the new species, which does not appear to be closely allied to any known member of either the *fitzingeri* or *rugulosus* groups.

#### The Status of *Hylodes berkenbuschii*

Savage (1975:271) regarded the eastern Mexico populations (1-2) of the *rugulosus* population system as morphologically distinct from other members of the *rugulosus* stock. Nevertheless he adopted a conservative position, since the distinctive populations were allopatric to typical *El. rugulosus* (Cope, 1870) and retained them within the latter species.

Subsequently, karyologic analysis of the *rugulosus* population system (De-

Weese, 1976) discerned that the eastern Mexico populations differed significantly from all other units in the *rugulosus* population system. The eastern Mexico populations have a diploid number (2N) of 22 and a *nombre fundamental* of 36. All other known members in the system have  $2N = 20$ . In this regard the eastern Mexico populations resemble *El. vocalis* of northwestern Mexico but differ from the latter form in chromosomal definition. These two forms are amply distinct morphologically (Savage, 1975). A more detailed discussion of karyologic features and evolution in the *rugulosus* group is in preparation by DeWeese.

The combination of morphologic differences supported by the unique karyology of the eastern Mexico populations force us to conclude that they represent a species distinct from *El. rugulosus*. The first available name for this form is *Hylodes berkenbuschii* W. Peters, 1870 (holotype: Berlin 6666; Mexico: Puebla: nr. Izucar de Matamoros). The species now to be called *Eleutherodactylus berkenbuschii* (W. Peters, 1870) is characterized by Savage (1975:270) and the distribution reviewed (pp. 271, 291–292). *El. berkenbuschii* may be most easily distinguished from *El. rugulosus* morphologically as follows (characteristics of the latter form in parentheses): canthus rostralis sharp (rounded) and first finger usually shorter than second finger (first finger usually longer than second).

Synonyms of *El. berkenbuschii* include *Eleutherodactylus natator* Taylor, 1939 (holotype: CM 1000014; Mexico: Veracruz: Tlilapam) and *Eleutherodactylus vulcani* Shannon and Werler, 1955 (holotype: Mexico: Veracruz: Volcan San Martin.)

#### Conventions and Acknowledgments

In order to reduce the number of times the long name *Eleutherodactylus* is spelled out in this and subsequent papers and to clearly distinguish it from other anuran groups when the generic name is abbreviated, we have adopted the form *El.* to represent the generic name. Those who know Spanish will note that this also provides an euphonious neatness to discussions of species in the genus since *el* is the Spanish definite article meaning "the." We have eschewed the use of diacritical marks on Spanish localities for the reasons given by Stuart (1963).

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